INFLUENCE OF UNDERSHIRT TYPE ON PHYSIOLOGICAL RESPONSES WHILE EXERCISING IN THE HEAT

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INTRODUCTION

Australian soldiers typically wear a 100% cotton t-shirt underneath their disruptive pattern combat uniform (DPCU). When working in hot environments it has been questioned whether removing the t-shirt would improve a soldier's heat loss capacity. Furthermore, in recent years there has been an emergence of tight-fitting polyester t-shirts and manufacturers claim that these garments will cool the body by wicking sweat away from the skin. Wickwire *et al* [1] found wearing a tight-fitting synthetic t-shirt, under protective body armour, had no effect on body heat loss. This is not surprising, as no evaporative heat loss can occur through the body armour. If, however, a polyester t-shirt is combined with a more permeable over-garment (i.e. combat uniform) a greater cooling effect may be possible. Therefore, the aim of this study was to determine whether i) wearing a t-shirt underneath DPCU reduces body heat loss and ii) wearing a tight-fitting polyester t-shirt improves body heat loss.

METHODS

Nine healthy, fit males (age 23.3±2.55 yrs; height 1.84±0.07 m; 81.9±7.21 kg) volunteered to participate in a treadmill-based test in 34.2 ±0.5ºC and 62.3 ±3.1% RH. Following 10 min of baseline data collection, participants completed a walk-run protocol (walk: 6 $km.hr^{-1}$ for 2 min; run: 10 $km.hr^{-1}$ for 4 min) for 40 min. Participants completed three trials, wearing a different clothing configuration in each trial. For all trials, participants wore their own runners and socks, a pair of tight-fitting polyester shorts and a set of DPCU trousers and long-sleeve shirt (75% cotton, 25% polyester). In addition, they either wore a tight-fitting polyester t-shirt (PS), a 100% cotton t-shirt (TS), or no t-shirt (NS) under their long-sleeve DPCU shirt. The order of t-shirt worn was balanced across participants.

Trials were conducted at the same time of the day and volunteers were fully hydrated (USG <1.020). Body core temperature (T_c) was measured using the telemetric pill. Skin temperature (T_{sk}) was measured at six sites and heart rate (HR) was measured continuously. Psychophysical measures included: rating of perceived exertion (RPE); thermal comfort (TC); thermal sensation

(TS); skin wettedness (SW) and clothing comfort (CC). A two-factor (t-shirt and time) design, repeated measures ANOVA was used for within-subject comparisons. Data is presented as means (± standard deviation).

RESULTS AND DISCUSSION

At the commencement of exercise, after 10 min of rest in the hot-humid environment, T_c, T_{sk} and HR were equivalent between trials. T_c consistently increased after 3 min of exercise until the end of the trial under all three conditions reaching 39.17±0.34˚C, 39.11±0.43˚C and 39.18±0.38˚C for the NS, TS and PS trials respectively. T_{sk} rapidly increased upon entering the chamber with a further smaller rise during the initial stages of exercise. The effect of the varied metabolic heat production between the running and walking phases of the exercise protocol was evident with corresponding fluctuations in T_{sk}. HR increased on entering the chamber, although the rate of increase was much higher once exercise commenced. At the end of the 40-min exercise bout HR was 185.4 ±13.7 beats.min^{-1}; 187.1 ±5.4 beats.min^{-1}; 188.2 ±8.9 beats.min^{-1} for NS, TS and PS respectively. However, there were no significant differences (P>0.05) in T_c, T_{sk} or HR between the three t-shirt conditions (Table 1). Considering the pronounced heat production combined with the limited avenues for heat loss in the hot-humid environment it is not entirely surprising that there were no observed between-trial difference for T_c and T_{sk}. A small difference in evaporative heat loss induced by removing a clothing layer or an alternate textile would be difficult to isolate in this current scenario.

Table 1: Mean physiological data during the 40-min walk: run protocol. Three conditions were assessed: no shirt (NS), cotton t-shirt (TS) and tight-fitting polyester t-shirt (PS).

	NS	**TS**	**PS**
T_c (°C)	38.20 (±0.64)	38.05 (±0.70)	38.17 (±0.65)
T_{sk} (°C)	35.77 (±0.44)	35.94 (±0.46)	35.80 (±0.47)
HR (beats.min^{-1})	157.2 (±26.9)	158.1 (±26.2)	160.6 (±24.7)

The final rating of perceived exertion values reached a rating of somewhat hard under all conditions. By the end of all trials, participants felt ‘warm’ to ‘hot’ and were ‘slightly uncomfortable’ to ‘uncomfortable’ with this thermal sensation. Furthermore, skin wettedness reached ‘wet’ and participant’s felt the clothing to be ‘slightly uncomfortable’. There were no significant differences between the three conditions for any of the psychophysical measurements (P>0.05; Table 2).

Table 2: Psychophysiological ratings immediately prior to completion of the 40-min walk: run protocol. Three conditions were assessed: no shirt (NS), cotton t-shirt (TS) and a tight-fitting polyester t-shirt (PS). Five psychophysical indices: rating of perceived exertion (RPE), thermal comfort (TC), thermal sensation (TS), skin wettedness (SW) and clothing comfort (CC).

	Scale	NS	TS	PS
RPE	6 to 20 (very, very light to very, very hard)	12.9 (±2.4)	13.4 (±1.6)	12.1 (±2.1)
TC	1 to 5 (comfortable to extremely uncomfortable)	2.8 (±0.9)	2.8 (±0.9)	2.6 (±1.1)
TS	1 to 13 (unbearably cold to unbearably hot)	9.9 (±0.6)	9.8 (±0.8)	10.3 (±0.7)
SW	0 to 10 (dry to dripping wet)	7.9 (±1.8)	7.7 (±1.5)	7.2 (±1.8)
CC	0 to 10 (very comfortable to extremely uncomfortable)	5.8 (±2.7)	5.6 (±2.1)	5.3 (±2.1)

CONCLUSIONS

In the current experimental scenario, where volunteers conducted high intensity work in a hot-humid environment, the removal of the t-shirt or the substitution of the 100% cotton with the tight-fitting polyester t-shirt did not provide any benefit to physiological or perceived strain indices. Consequently the manufacturers' claims that tight-fitting polyester t-shirt can improve thermoregulation by exacerbating heat loss cannot be substantiated.

REFERENCES

1. Wickwire, J., et al., *Physiological and comfort effects of commercial "wicking" clothing under a bulletproof vest.* International Journal of Industrial Ergonomics, 2007. 37: p. 643-651.